CAPITAL WIND FARM - INVESTIGATION OF POSSIBLE IMPACTS ON BROADCASTING AND RADIOCOMMUNICATION SERVICES

PHASE 1

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L. J. Derrick B. E. (Elec.) ACA Accreditation No 008
Lawrence Derrick & Associates
Engineering Consultants & RF Frequency Assigners

CONTENTS

ATTACHMENTS

1. BACKGROUND

Renewable Power Ventures is proposing to construct a wind farm in the Bungendore - Tarago area of NSW, 55 km north east of Canberra, ACT. This will involve the construction of 63 wind turbines, which consist of 80 metre high tapered cylindrical metal towers with three 44 metre bladed turbines mounted on top. As part of the environmental study of the proposal, the potential for disruption to radiocommunications and broadcasting in the wind farm area is being assessed. Clearance distances between any point to point microwave link paths and the turbines are also required to be established to avoid any degradation to the performance of the links.

2. INTRODUCTION

It is considered necessary to include an assessment of impacts of the wind turbines on TV and sound broadcasting reception in the general area of the wind farm from the transmitting stations utilised by residents and to determine if any of the turbines are close to microwave system paths traversing the wind farm site. This report covers the outcomes of a Phase 1 desktop study as outlined below.

3. INVESTIGATION PHASES

If necessary a two-phase investigation could be undertaken to determine possible impacts on broadcasting and radiocommunication services, with Phase 2 consisting of two parts:

Phase 1 - Desktop Study and Report

Phase 2, Part 1 - Area Visit, TV Survey of Dwellings and Validation of Communications Link Data and Report

Phase 2, Part 2 - Finalisation of Conclusions and Report after Location of Turbines confirmed and Turbine Type Selected.

This Report covers Phase 1 only.

4. Phase 1

In Phase 1 a desk top study has been made of the likely impact of typical wind farm turbines and their supporting towers on broadcasting and radiocommunications in the area surrounding the wind farm. This study is based on relevant International Telecommunications Union (ITU) documents and on other professional reports on overseas and Australian experience of wind farm impacts on broadcasting and radiocommunication services up to 10 km from any wind turbine structures. Theoretical estimates, based on the University of Michigan method in Ref. 1, have been made of the magnitude and location of any effects. These are summarised in Attachment 10.

Using data from the Australian Communications & Media Authority's (ACMA) RADCOM Database, checks have been made on radiocommunication services

within at least a 30 km radius of the wind farm to determine if any of the turbine towers could obstruct line-of-site paths or have any likely detrimental affect on these services. The assessments in this Report are based on a 63 turbine layout of the wind farm area (locations are listed in Attachment 1). Clearance criteria have been indicated for point to point radio paths crossing or near the wind farm site and are discussed in Attachment 9.

5. BROADCASTING SERVICES IN THE AREA

From ACMA TV and Sound Broadcasting Station listings, and from a map survey of the area surrounding the Capital wind farm site, the following is a general summary of the broadcast transmitter site locations and radio frequency channels which cover the area. ACMA Digital Channel Plans and Explanatory Papers on Digital Terrestrial Television Broadcasting for NSW and the ACT (Refs. 9 - 12) were also examined for plans for digital television introduction in the area.

5.1 Television

It is expected that Bungendore area residents generally view analogue TV from National main stations ABC9 and SBS28 and Commercial stations CTC7, WIN31, CBN34, located at Black Mountain, Canberra. Digital TV is also available from this site on channels 6, 9A, 11, 12, & 30. Although the southern end of the wind farm is only about 40 km from Black Mountain reception of TV signals becomes patchy or impossible to the north due to the shielding of the Lake George Range and local undulations. Signals from the more distant Illawarra TV stations on Knights Hill are understood to be utilised north of Bungendore including at Tarago. National Stations SBS53 & ABWN56 and commercial stations WIN59, CTC62 & CBN65 are available. Digital channels available are 36, 37, 38, 51 & 54 Some homesteads will be in “black holes” for terrestrial TV reception and would use satellite TV.

5.2 FM Sound Broadcasting

National, Community and Commercial services on 91.1, 91.9, 92.7, 98.3, 101.5, 102.3, 104.7, 105.5, 106.3, Mhz are transmitted from Black Mountain. .From Knight’s Hill, Illawarra, National FM Stations transmit on 95.7, 97.3, 98.9 Mhz. It is expected that a number of these FM transmissions will be receivable in the wind farm area, the actual ones received at each homestead depending on the degree of obstruction on the individual paths from each station

5.3 MF Sound Broadcasting

As indicated below, wind farm effects on MF radio are highly unlikely and therefore the stations serving the area have not been listed.

5.4 Satellite Pay Television

Some homesteads in the area may have satellite pay TV service antenna installations. Unless a particular subscribers antenna reception direction and

elevation is closely aligned in azimuth and elevation with a turbine no impacts on TV reception is likely.

6. RADIOCOMMUNICATIONS SERVICES

An extract of the ACMA database is shown in Attachment 2. This lists all point to point services on a grid of 60 km x 60 km centred on the wind farm. Other omnidirectional facilities such as cellular and private mobile base stations have also been examined for any potential impact.

6.1 Point to Point

A large number of point to point links are registered for operation within 30 km of the wind farm site. Two radio sites within the wind farm area at Cowley Hills and Mt Allianoyonoyiga have three low capacity UHF point to point links established which potentially could be impacted by turbines. These links are operated by the NSW Rural Fire Service and the Ambulance Service of NSW. An Optus microwave link between Bungendore and Gearys Gap also crosses the edge of the wind farm area. It would be prudent to maintain adequate clearance between these link path bearings and the turbines if reasonably possible.

6.2 GSM/CDMA Mobile

There is a Telstra GSM or CDMA service registered at Gearys Gap which is some distance from any turbine. There are probably Optus and Vodafone bases at the micriwave site at Collector.

6.3 Two-Way Mobile

A number of private and Public Utility Point to Multipoint and mobile bases exist in the area surrounding the wind farm site. These bases potentially provide cover to mobiles in a 360 degree arc from their bases. No significant impact from the wind farm on base coverage beyond normal mobile operational performance is predicted in view of the geographic separation between the base antennas and the turbine structures. Of course a mobile unit communicating with a base station when the mobile is located within metres of the wind turbine structures (or indeed near any large building, silo, tower etc) may experience some very local performance change, however moving a short distance would restore performance to normal.

6.4 CB Radio

CB radios are not individually licensed, the equipment being subject to class licensing only. Therefore no records of location or operators of CB radios exist, and the channels are shared without any right of protection from interference. No impact from the wind farm is predicted except perhaps for very local effects to portable or mobile units in the immediate vicinity of the turbines which could be avoided by a small location change of the unit.

6.5 Other Services

The nearest Air Services Australia Radio Site is about 30 km away at the Canberra Airport to the south west. The Canberra airport has a Radar installation on Mt Majura.

7. EMI EFFECTS OF WIND TURBINES

The following is an extract from Ref. 1:

> "It is well known that any large structure, whether stationary or moving, in the vicinity of a receiver or transmitter of electromagnetic signals may interfere with those signals and degrade the performance of the transmitter/receiver system. Under certain conditions, the rotor blades of an operating wind turbine may passively reflect a transmitted signal, so that both the transmitted signal and a delayed interference signal (varying periodically at the blade passage frequency) may exist simultaneously in a zone near the turbine. The nature and amount of electromagnetic interference (EMI) in this zone depend on a number of parameters, including location of the wind turbine relative to the transmitter and receiver, type of wind turbine, physical and electrical characteristics of the rotor blades, signal frequency and modulation scheme, receiver antenna characteristics, and the radio wave propagation in the local atmosphere. Other wind turbine components which have been considered to be potential causes of EMI are towers and electrical systems. However, neither of these has been found to be a significant source of interference. Thus, moving blades are the components of most importance in determining EMI levels.
>
> TVI from wind turbines is characterised by video distortion that generally occurs in the form of a jittering of the picture that is synchronised with the blade passage frequency.
>
> Effects on FM broadcast reception have been observed only in laboratory simulations."

Point to point links in microwave and lower frequency bands will be affected only if the turbine tower or turbine clearance to the line of site path to the other end of the link is within the first Fresnel zone which is dependent on the operating frequency of the link, the distance of the tower/turbine from the link antenna and the total link distance. D. F. Bacon(Ref. 8) proposes 3 potential degradation mechanisms - near field effects, diffraction and reflection or scattering. The reflection or scattering treatment in the reference suggests greater clearance requirements at positions close to the link terminals than the usually applied Fresnel Zone clearance.

8. DISCUSSION OF OVERSEAS EXPERIENCE

Observations and studies have been carried for a number of years in both the USA and the UK on the effects of wind turbines on TV and other radiocommunication services. In 1976 the US Energy Research and Development Administration (ERDA) funded the RadLab at the University of

Michigan for investigations into these effects and this continued for 7 years. Ref. 1 summarises the results of theoretical and field measurements.

The BBC's Research Department in the UK has also investigated this subject in some depth, and in 1983 a report was issued (Ref. 2). Another Report (Ref. 3) was issued in 1992 after the Research Department had carried out observations from test transmissions at existing wind farms in Denmark in 1991.

In 1992 the ITU issued a Recommendation (Ref. 4) on the assessment of impairment caused to television reception by a wind turbine.

In a recent exchange of emails, Mr Chris Gandy of the BBC Research Department summarised the conclusions they had come to on this subject as follows - "…..in the UK the only significant broadcast reception difficulties that have successfully been attributed to wind turbines so far have been associated with UHF analogue television, not FM radio and certainly not MF or LF radio. There may be some potential for effects on digital terrestrial television, but possibly only in cases where turbine blades are between the transmitter and the receiver - cases of reflection from the blades are much more common and in the majority of cases should do little damage to our DTT signals because of the guard interval present in each DVB signal. Of course, there will be the odd case where reception was right on the edge of the 'digital cliff' before the turbines were built. Also we have no record of interference with our Digital Radio transmissions in Band III."

Ref. 5 summarises the results of model measurements of the level of interference signals scattered by turbine blades and the supporting tower and confirms some of the backscatter estimates calculated in Ref. 4.

It is believed that metal blades were used on the earlier turbines unlike the modern ones where composite material - fibre glass, carbon fibre, plastics are used. In some cases metal exists in the composite material blades for strength reinforcing or for lightning protection. Some references indicate that the composite blades will have a reduced interference potential, however the BBC view is that at UHF TV frequencies the difference will be small.

It is also indicated in some of the reports that due to variable wind speeds and direction, the resulting changes to turbine blade pitch and turbine facing direction will modify any interference levels at a given location in the service area ie interference effects would be time variant.

From a study of the above references and others, the following general conclusions are drawn:

(a) No turbine interference effects are expected to MF radio reception.

(b) There is a very low probability of perceptible interference to FM radio reception, and under most situations any interference to VHF TV reception would be limited to locations very close to the turbines.

(c) Some interference may be experienced to UHF TV reception and particularly where the path to the TV transmitter for a given receiver

location is through the wind turbine blades or where there is a partly obstructed path to the transmitter and there is a clear path to a turbine. These effects may be restricted up to a maximum distance of about 5 km from the wind farm in forward scatter directions (receiver on opposite side of the wind farm to the sought after TV station).

(d) Digital TV services are unlikely to suffer degraded picture quality unless the signal strength is low and near a threshold level. In effect, a reduction in service area could occur due to reflected signals.

9. CAPITAL WIND FARM SITUATION

From overseas experience, calculations using the University of Michigan method and the topography of the area:

9.1 No interference from the wind farm is expected to the MF and FM sound broadcasting services in the area.

9.2 Estimates, outlined in Attachment 10, of reflections of the existing National and Commercial analogue VHF TV transmissions from Black Mountain by the turbine blades indicate that some possibility of TV picture degradation exists at times for dwellings located such that wind turbines exist within a +/- 25 degree sector (Ref. 6) from the TV antenna nominal direction of reception , and up to about 1 km from the turbines. Estimates of scattering from the blades are based on an assumption that the three blades each have a one sided projected surface area of 67 sq. metres (44 metres long), that the turbine towers will be tapered steel columns 80 metres high and on using the method outlined in Ref.1. Some measurements overseas indicate that the calculations using the alternative ITU method (Ref.4) over estimate the scattering /reflection so this method has not been used. It is also difficult to estimate the additive effects of a number of turbines distributed over some distance and on the effect of the undulating terrain on the ratio of the reflected signal to the main wanted TV signal. Predictions for the UHF TV transmissions from Black Mountain and Knights Hill also indicate the time variant possibility of picture degradation for dwellings located with wind turbines visible within + or – 20 degrees (Ref. 6) of the viewed TV station bearing and at distances up to and in excess of 1km. In view of the obstructed or long distant paths to the two possible main TV station sources It is difficult to predict which particular properties within say 2 Km of a turbine may experience TV degradation without a survey of the current TV situation in the area being carried out. Those homesteads currently utilising satellite TV would probably not be affected by turbines.

9.3 As indicated above, digital television is not subject to ghosting degradation, however some reduction of service area could result from reflected unwanted signals at the limits of the service area. Digital TV Channels are being transmitted from Black Mountain and Knights Hill.

9.4 There are no TV rebroadcast stations listed in the area surrounding the wind farm. The turbines will, therefore, have no impact on rebroadcast signal quality.

9.5 For satellite pay TV services in the area of the wind farm no interference to these services is likely to occur unless the required pointing of their dish antennas to the serving satellite is also in line with a turbine.

9.6 An extract from the ACMA RADCOM database (Attachment 2.) has been studied for services within at least 30 km of any wind farm turbine to determine if any point to point services will have their paths obstructed by the wind turbine blades or the supporting towers. There are a three UHF Links and an Optus microwave link which traverse the wind farm area.. All line of sight paths appear to have either vertical or horizontal clearance based on the nominal turbine sites. Path profiles for the microwave system and three UHF links are shown in Attachments 4, 5,6&7. Attachment 9 lists the links the calculated bearings and the clearance necessary based on Ref. 8. The bulk of the links are single channel UHF types for various operators and there is a microwave link operated by Optus. It is considered that the recommended clearances are met for all links. The clearance criteria adopted is the second fresnel radius to be maintained between the link ray line and the tip of the blade in the horizontal positions on either side of the support tower or vertically below. The clearance at a turbine position required depends on individual link frequencies and distance from the radio site and some examples are given in Attachment 9 with the appropriate formula.

9.7 The nearest registered Telstra cellular base at Gearys Gap and other possible Optus and Vodafone sites at Collector are too far from the turbines to impact their coverage.

9.8 The Airservices facility on Mt Majura includes Radar. UK Interim Guidelines (Ref.13) on siting of wind farms near civil and military aviation facilities indicates that consultation is required for turbines within 30 km of Radar and other technical facilities however turbines farther away than 30 km may be a factor if they are in line of sight. The Ministry of Defence (UK) will not accept any application for a wind turbine within 74 km of an air defence site unless developers can prove that it will have no impact on the radar concerned. The Canberra airport uses the Radar installation on Mt Majura. Path profiles from this site to the southern wind turbines in at least one group indicate that some will be in LOS and will be at just over 30 km separation from the Radar site. If is has not already been done it recommended that Air Services and other Aviation interests be requested to confirm that there do not foresee any unacceptable impact to the radar operation.

10. FORTUITOUS RECEPTION OF BROADCAST SIGNALS

On some previous projects Responsible Authorities have imposed conditions such as:
"if the qualitative survey establishes any detrimental increase in interference to reception and/or signals, the applicant shall implement mitigation measures……"

This raises two issues, the first being the criteria for interference assessment and the second being the protection of reception of some services outside their designed coverage area - termed fortuitous reception. For television reception which will be the main focus of this investigation it is proposed to use the ITU grade 4, of a 5 grade impairment scale as the limit of acceptance, which is described as "perceptible but not annoying". On the second point, the ACMA's attitude to protection of reception outside designed service areas is understood to be that the reception is fortuitous and will not be protected. They will therefore plan for reuse of frequencies for new stations which in future may impair reception in areas where it is currently acceptable or useable, often for at least part of the time.

This is, of course, difficult for individuals to accept who, due to their particular location, cannot receive an acceptable service from their planned station. Others use distant stations to avail themselves of diverse programs. It is not reasonable to attempt to protect these services which may vary in quality of reception depending on time of day and season. In the Capital case no survey has been done on whether the residents close to the wind farm receive TV from any other transmitting station than other than Canberra or Illawarra.

11. MITIGATION TECHNIQUES

For individuals living close a turbine who experience a degraded FM or TV broadcasting service due to identified interference from the wind farm, possible techniques to reduce the interference to acceptable limits include:

1. Replacement of receiving antenna system with a higher gain more directive pattern model,

2. Reposition antenna in height or horizontally on the dwelling,

3. Install an antenna elsewhere on the property and cable to dwelling,

4. Change the orientation of antennas to receive an alternative station if available,

5. Use any available digital TV Channels instead of analogue (requiring a digital converter or digital TV set), and

6. Provision of an alternative satellite service eg, Austar Pay TV Service.

Potential mobile base coverage conflict is not predicted

Any minor affects to MF broadcasting would occur within 10's of metres of the turbines only and with a buffer zone of at least 500m to any dwelling, no corrective action will be required.

Any potential obstruction to point to point links may be avoided by horizontal positioning of the offending turbine. For the single channel UHF links some

degree of obstruction may not significantly impact on their performance and this could be studied further.

12. CONCLUSIONS

Interference to MF and FM sound broadcasting is not expected.

Sufficient clearance between point to point radio systems that traverse the wind farm area and the wind turbines will be maintained based on the details of radio systems in the ACMA Radcom data base . Clearances are recommended in Attachment 9. Other radiocommunication services in the area are not expected to be impacted by the wind farm or its operation.

VHF TV reception at dwellings within about 1 – 2 km of the wind farm turbines and with antennas having turbines located with +/- 25 degrees angle of their reception direction will have some probability of noticeable ghosting at times. For UHF TV time variant ghosting may be evident out to 2 - 3 km for turbines located +/- 20 degrees from the reception direction. There are a few homesteads which meet the above criteria for TV reception from either Black Mountain or Knights Hill. Whether the turbines produce perceptible ghosting will depend to a degree on whether a satisfactory level of signal is received over not too heavily obstructed paths to the transmitters at Black Mountain or Knights Hill. Due to the low population density in the area within say 5 km of the turbines there is a potential to impact a small number of residents.

Digital TV is not susceptible to visible ghosting degradation except at the extremities of the service area. Any impact of reflections from the turbines would be a minor reduction of coverage at the limit of the service area.

For any confirmed wind farm interference problems where TV receive antenna system improvements are unsuccessful, the use of an alternative satellite TV services in the area may be the best solution. Digital TV services are expect to provide unimpaired picture quality to any houses near the turbines which may have experienced picture quality problems as a result of ghosting from the turbines (subject to signals being above a threshold level).

As indicated above the southern turbines are just over 30 km from an Airservices radar station on Mt Majura and some are line of sight. Based on UK guidelines the aviation authorities would need to assess the situation in regard to false echoes or degradation of the radar coverage at low angles.

Overseas experience indicates that electrical interference from wind farm generators and controls is not a problem with reputable world class wind turbine manufacturers and therefore no electrical noise measurements are warranted.

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1. David E Spera, Wind Turbine Technology, Chapter 9 ASME Press 1994

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Denmark Nov 1991, BBC Research Department Report 1992/7

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9. Australian Broadcasting Authority, Digital Terrestrial Television Broadcasting, Variation to National Digital Channel Plans Australian Capital Territory : May 2002

10 Australian Broadcasting Authority, Digital Terrestrial Television Broadcasting, Variation to Commercial Digital Channel Plans Australian Capital Territory ; May 2002

11 Australian Broadcasting Authority, Digital Terrestrial Television Broadcasting, Variation to National Digital Channel Plans New South Wales: Part 1 – Sydney, Newcastle, Wollongong and Central Coast ; August 2003

12 Australian Broadcasting Authority, Digital Terrestrial Television Broadcasting, Variation to Commercial Digital Channel Plans New South Wales: Part 1 – Sydney, Newcastle, Wollongong and Central Coast ; August 2003

13 Wind Energy and Aviation Interests - Interim Guidelines, Wind Energy, Defence & Civil Aviation Interests Working Group UK Crown Copyright 2002. ETSU W/140626/REP

ATTACHMENT 1- Wind Turbine Locations Capital Wind Farm

Turbine	Easting	Northing
1	725661	6113444
2	725709	6113183
3	725590	6112912
4	726734	6112902
5	726656	6112651
6	729109	6113887
7	729059	6113668
8	729037	6113439
9	729184	6113193
10	729004	6113046
11	728840	6112886
12	728640	6112787
13	728456	6112662
14	728496	6112441
15	728557	6112228
16	728150	6112202
17	728153	6111976
18	725111	6108764
19	725035	6108549
20	724959	6108338
21	724878	6108127
22	726503	6107911
23	726081	6107782
24	726013	6107555
25	725706	6107394
26	725575	6107190
27	725768	6106864
28	725620	6106620
29	725494	6106397
30	725561	6106182
31	725531	6105955
32	725537	6105727
33	727715	6108175
34	727768	6107948
35	729753	6108832
36	730225	6108624
37	730244	6108404
38	730176	6108197
39	731402	6107916
40	731222	6107738
41	731157	6107496
42	730698	6107547
43	730685	6107322
44	730518	6107153
45	730130	6107203
46	730068	6106990
47	730195	6106598
48	729805	6106470
49	729775	6106250
50	729638	6106076
51	729701	6105864
52	729499	6105786
53	729360	6105616

54	729283	6105411
55	729145	6105235
56	729080	6104991
57	729528	6105166
58	729452	6104805
59	729361	6104602
60	728868	6104611
61	729231	6104414
62	729260	6104174
63	729225	6103957

Grid References Datum WGS 84 Zone 55

ATTACHMENT 2 *ACMA Point to Point Registrations within 30Km*

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
42650000	0	71	TransGrid	Commsite LERIDA	55	716970	6132360
150187500	12	109	Telstra	Lot 89 Hoskington Rd BOMBAY	55	738832	6079713
154787500	12	109	Telstra	Lot 89 Hoskington Rd BOMBAY	55	738832	6079713
404075000	15	215	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
404075000	10	216	NSW Rural	Gibraltar Street BUNGENDORE	55	721893	6095758
404075000	0	194	NSW Rural	Fire Control Centre Ellerton Street QUEANBEYAN	55	703520	6086450
404150000	0	186	Ambulance	Commsite LERIDA	55	716970	6132360
404175000	30	022	Mulwaree	Council Site COWLEY HILLS	55	736901	6119100
404400000	10	206	Ambulance	Commsite LERIDA	55	716970	6132360
404400000	0	014	Ambulance	The Ridgeway Reservoir QUEANBEYAN	55	705840	6086580
404400000	0	194	Ambulance	Commsite LERIDA	55	716970	6132360
404650000	0	347	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
404750000	10	032	Ambulance	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
404850000	0	115	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
404850000	10	063	Ambulance	Commsite LERIDA	55	716970	6132360
413525000	15	215	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
413525000	10	216	NSW Rural	Gibraltar Street BUNGENDORE	55	721893	6095758
413525000	0	194	NSW Rural	Fire Control Centre Ellerton Street QUEANBEYAN	55	703520	6086450
413600000	0	186	Ambulance	Commsite LERIDA	55	716970	6132360
413625000	30	022	Mulwaree	Council Site COWLEY HILLS	55	736901	6119100
413850000	10	206	Ambulance	Commsite LERIDA	55	716970	6132360
413850000	0	014	Ambulance	The Ridgeway Reservoir QUEANBEYAN	55	705840	6086580
413850000	0	194	Ambulance	Commsite LERIDA	55	716970	6132360
414100000	0	347	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
414200000	10	032	Ambulance	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
414300000	0	115	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
414300000	10	063	Ambulance	Commsite LERIDA	55	716970	6132360
450525000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
450550000	20	027	Country	Council Site COWLEY HILLS	55	736901	6119100
450675000	0	187	Woden	59 Hinksman St QUEANBEYAN	55	703170	6086590
450775000	0	32	Commissioner	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
450825000	0	74	New South	41 Campbell St QUEANBEYAN	55	702461	6085634
450825000	0	254	New South	The Ridgeway Reservoir QUEANBEYAN	55	705840	6086580
451150000	0	025	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451150000	0	205	Country	34 Lowe Street QUEANBEYAN	55	702650	6086320
451225000	0	228	Ambulance	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
451250000	0	329	Telstra	Telstra commsite GUN GUN	55	713598	6135241
451250000	0	323	Telstra	Telstra commsite GUN GUN	55	713598	6135241
451325000	0	027	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
451450000	0	247	NSW Rural	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
451475000	0	36	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	216	Country	STCC Depot Endurance Ave QUEANBEYAN	55	703850	6086720
451475000	0	141	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	67	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	247	Country	Coolebah Crescent QUEANBEYAN	55	702330	6083570
451475000	0	269	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	1	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	205	Country	34 Lowe Street QUEANBEYAN	55	702650	6086320
451475000	0	1	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
451475000	0	181	Country	Railway Parade OAKS ESTATE	55	701220	6086850
460025000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
460050000	20	027	Country	Council Site COWLEY HILLS	55	736901	6119100
460175000	0	187	Woden	59 Hinksman St QUEANBEYAN	55	703170	6086590
460275000	0	32	Commissioner	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
460325000	0	254	New South	The Ridgeway Reservoir QUEANBEYAN	55	705840	6086580

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
460325000	0	74	New South	41 Campbell St QUEANBEYAN	55	702461	6085634
460650000	0	025	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460650000	0	205	Country	34 Lowe Street QUEANBEYAN	55	702650	6086320
460725000	0	228	Ambulance	Mt Allianoyonyiga (Near Woodlawn Mines) TARAGO	55	733740	6119590
460750000	0	329	Telstra	Telstra commsite GUN GUN	55	713598	6135241
460750000	0	323	Telstra	Telstra commsite GUN GUN	55	713598	6135241
460825000	0	027	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
460950000	0	247	NSW Rural	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
460975000	0	36	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	216	Country	STCC Depot Endurance Ave QUEANBEYAN	55	703850	6086720
460975000	0	141	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	67	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	247	Country	Coolebah Crescent QUEANBEYAN	55	702330	6083570
460975000	0	269	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	1	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	205	Country	34 Lowe Street QUEANBEYAN	55	702650	6086320
460975000	0	1	Country	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
460975000	0	181	Country	Railway Parade OAKS ESTATE	55	701220	6086850
848200000	10	227	Capital Media	NTA Site BYWONG HILL	55	708300	6107800
848600000	10	41	Queanbeyan	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
848600000	10	221	Queanbeyan	QBN FM Studio 261 Crawford Street QUEANBEYAN	55	702940	6085140
849400000	15	206	Capital Media	Lot 3 Cnr Marked Tree Rd & Rosamel St GUNDAROO	55	707230	6122010
852012500	15	192	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
852137500	10	62	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
852237500	30	050	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
852362500	0	179	Commissioner	Forestry Commission Fire Tower KOWEN FOREST	55	706660	6093770
852387500	15	69	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
852487500	0	192	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
852562500	10	213	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
852812500	4	261	Geoscience	Canberra Magnetic Observatory KOWEN FOREST	55	715700	6089500
852862500	20	261	Canberra	Queanbeyan Hospital Collett Street QUEANBEYAN	55	702800	6085900
854300000	30	64	Commissioner	Commsite LERIDA	55	716970	6132360
854700000	30	186	Commissioner	Commsite LERIDA	55	716970	6132360
855500000	10	248	Ambulance	Commsite LERIDA	55	716970	6132360
856300000	10	063	Ambulance	Commsite LERIDA	55	716970	6132360
877860000	25	350	Telstra	Tarago Roadbase Quarry Near the Corner of	55	743616	6116295
884670000	15	270	Telstra	Crest Road QUEANBEYAN	55	701325	6085575
884670000	15	30	Telstra	Crest Road QUEANBEYAN	55	701325	6085575
884670000	15	150	Telstra	Crest Road QUEANBEYAN	55	701325	6085575
884670000	25	350	Telstra	Tarago Roadbase Quarry Near the Corner of	55	743616	6116295
928012500	15	192	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
928137500	10	62	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
928237500	30	050	NSW Rural	Council Site COWLEY HILLS	55	736901	6119100
928362500	0	179	Commissioner	Forestry Commission Fire Tower KOWEN FOREST	55	706660	6093770
928387500	15	69	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
928487500	0	192	Commissioner	Near Kings Highway Bungendore BALD HILL	55	717550	6090450
928562500	10	213	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
928812500	4	261	Geoscience	Canberra Magnetic Observatory KOWEN FOREST	55	715700	6089500
928862500	20	261	Canberra	Queanbeyan Hospital Collett Street QUEANBEYAN	55	702800	6085900
928912500	20	261	Canberra	Queanbeyan Hospital Collett Street QUEANBEYAN	55	702800	6085900
930300000	30	64	Commissioner	Commsite LERIDA	55	716970	6132360
930700000	30	186	Commissioner	Commsite LERIDA	55	716970	6132360
931500000	10	248	Ambulance	Commsite LERIDA	55	716970	6132360
932300000	10	063	Ambulance	Commsite LERIDA	55	716970	6132360
1444500000	40	61	Commissioner	Commsite LERIDA	55	716970	6132360
1446500000	25	304	TransGrid	Railway Parade OAKS ESTATE	55	701220	6086850
1450500000	35	185	Commissioner	Commsite LERIDA	55	716970	6132360
1505000000	40	61	Commissioner	Commsite LERIDA	55	716970	6132360

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
1507000000	25	304	TransGrid	Railway Parade OAKS ESTATE	55	701220	6086850
1511000000	35	185	Commissioner	Commsite LERIDA	55	716970	6132360
1734500000	6	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
1741500000	44	209	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
1755500000	6	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
1853500000	6	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
1860500000	44	209	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
1874500000	6	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
2127600000	20	10	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2127600000	20	180	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2127600000	20	270	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2127600000	24	330	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500
2127600000	24	140	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500
2127600000	24	220	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500
2127600000	14	30	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2127600000	14	150	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2127600000	14	270	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2127600000	24	80	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2127600000	24	200	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2127600000	24	320	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2127600000	20	30	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
2127600000	20	100	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
2127600000	20	240	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
2155100000	20	10	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2155100000	20	180	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2155100000	20	270	Telstra 3G	15 Silva Ave LARMER	55	704011	6086515
2155100000	24	330	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500
2155100000	24	140	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500
2155100000	24	220	Telstra 3G	6 Kealman Street QUEANBEYAN	55	700600	6085500

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
2155100000	14	30	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2155100000	14	150	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2155100000	14	270	Telstra 3G	Crest Road QUEANBEYAN	55	701325	6085575
2155100000	24	80	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2155100000	24	200	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2155100000	24	320	Telstra 3G	7 - 9 Morisset Street QUEANBEYAN	55	702573	6085211
2155100000	20	30	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
2155100000	20	100	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
2155100000	20	240	Telstra 3G	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
3610000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3610000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3650000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3650000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3690000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3690000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3730000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3730000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3770000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3770000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3850000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3850000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3930000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3930000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3970000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
3970000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4010000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4010000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4050000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4050000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
4090000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4090000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4170000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4170000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
4550000000	32	60	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4590000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4630000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4670000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4850000000	32	60	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4890000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4930000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
4970000000	32	060	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
5945200000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
5945200000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6004500000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6004500000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6197240000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6197240000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6256540000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6256540000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6500000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6580000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6620000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6620000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6660000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6700000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6700000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6740000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6740000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
6740000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6840000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6920000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
6960000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
6960000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7000000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7040000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7040000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7080000000	0	69	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7080000000	0	209	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7080000000	20	205	Digital	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7296000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
7376000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
7431500000	25	61	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7456000000	36	61	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7463000000	0	315	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7487500000	0	209	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7501500000	50	60	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
7512000000	0	315	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7515500000	0	232	Telstra	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
7520000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
7524250000	30	32	Airservices	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7531250000	30	208	Airservices	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7543500000	20	062	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7543500000	20	280	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7557500000	20	062	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7557500000	20	280	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7592500000	25	61	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7600000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937

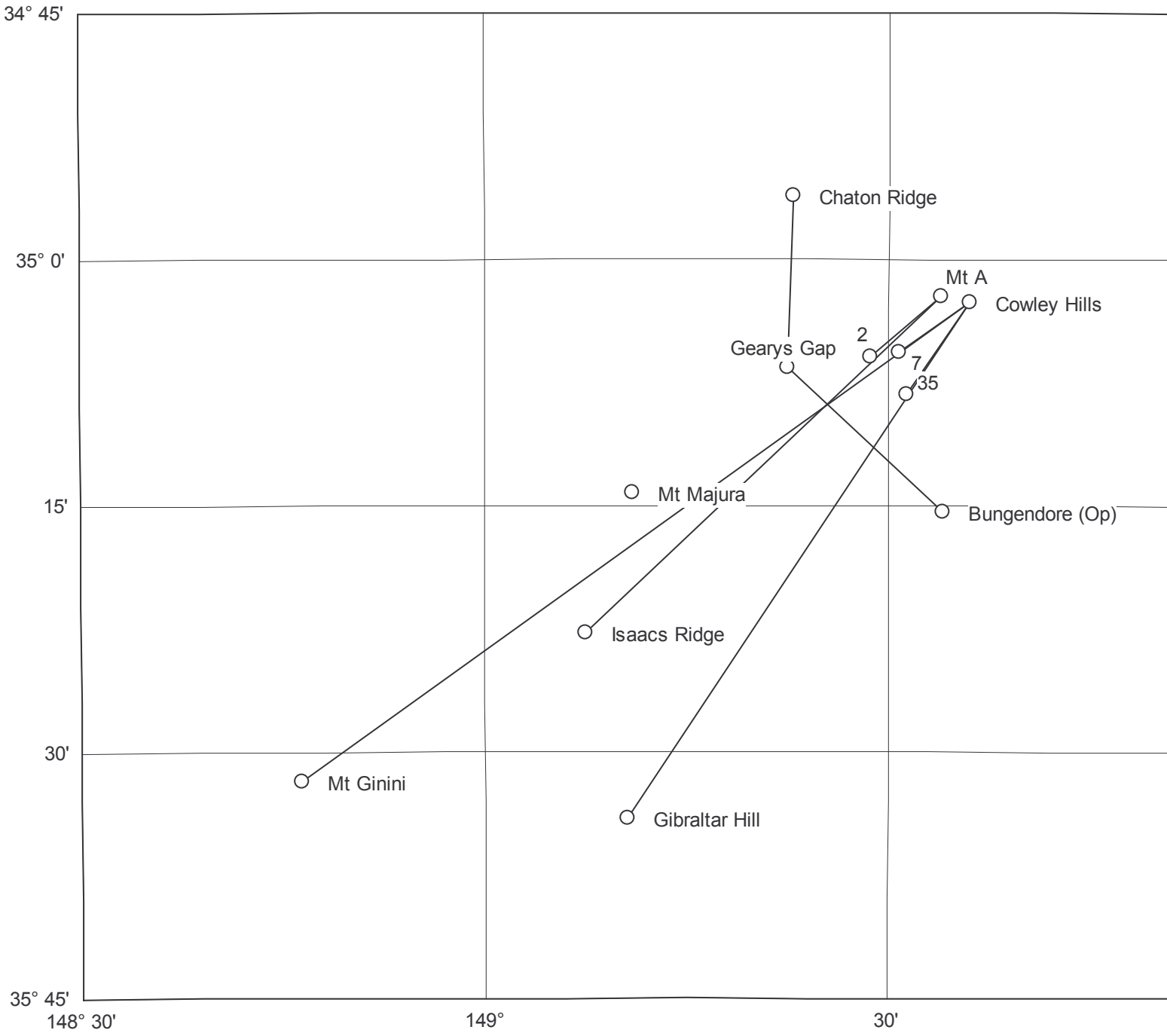
FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
7617000000	36	61	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7624000000	0	315	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7648500000	0	209	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7662500000	50	60	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
7673000000	0	315	Telstra	Telstra commsite GUN GUN	55	713598	6135241
7676500000	0	232	Telstra	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
7685250000	30	32	Airservices	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7692250000	30	208	Airservices	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
7704500000	20	062	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7704500000	20	280	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7718500000	20	062	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7718500000	20	280	Soul Pattinson	Commsite LERIDA	55	716970	6132360
7732875000	0	216	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7732875000	0	062	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7732875000	35	230	TransGrid	Commsite LERIDA	55	716970	6132360
7749800000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
7762525000	0	62	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7762525000	0	215	Prime	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7792175000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7851475000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7851475000	0	062	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7851475000	21	050	TransGrid	Commsite LERIDA	55	716970	6132360
7881125000	0	62	Prime	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7910775000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
7946000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
8026000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
8044195000	0	216	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8044195000	0	062	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8044195000	35	230	TransGrid	Commsite LERIDA	55	716970	6132360

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
8073845000	0	62	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8073845000	0	215	Prime	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8103495000	0	215	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8133145000	0	62	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8162795000	0	216	Australian	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8162795000	21	050	TransGrid	Commsite LERIDA	55	716970	6132360
8170000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
8192445000	0	62	Prime	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
8250000000	10	012	Department of	HMAS Harman BONSHAW	55	699937	6085937
8251745000	0	62	WIN Television	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
10558000000	32	256	Vodafone	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
10558000000	19	204	Telstra	Dairy Creek Road GUNDAROO	55	709025	6120929
10572000000	40	292	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
10586000000	36	183	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
10586000000	50	003	Vodafone	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
10586000000	36	308	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
10603500000	18	321	Telstra	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
10623000000	32	256	Vodafone	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
10623000000	19	204	Telstra	Dairy Creek Road GUNDAROO	55	709025	6120929
10637000000	40	292	Telstra	Air Services Australia Site Chaton Ridge LAKE	55	717340	6131340
10651000000	36	183	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
10651000000	50	003	Vodafone	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
10651000000	36	308	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
10668500000	18	321	Telstra	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
12765000000	38	7.4	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
12821000000	5	302	Soul Pattinson	Illawarra Institute of Technology Cnr Buttle and	55	703868	6085675
13031000000	38	7.4	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
13087000000	5	302	Soul Pattinson	Illawarra Institute of Technology Cnr Buttle and	55	703868	6085675
14511500000	26	251	Optus Mobile	Manar North 3721 Kings Hwy BUNGENDORE	55	733451	6095261

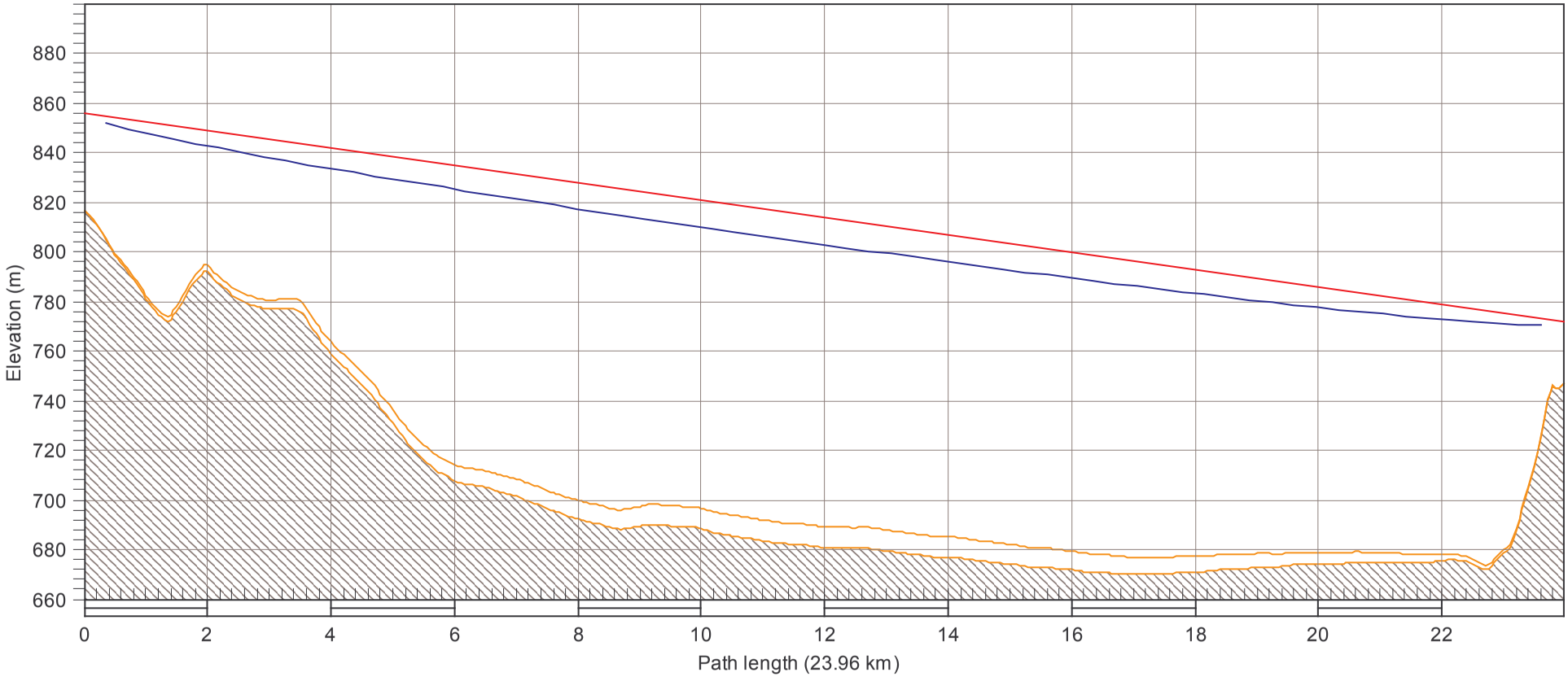
FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
14511500000	17	71	Optus Mobile	Gumnut Highland Cattle Stud Kings Highway	55	717644	6090407
14550000000	39	313	Optus Mobile	Manar North 3721 Kings Hwy BUNGENDORE	55	733451	6095261
14550000000	25	133	Optus Mobile	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
14550000000	10	4.3	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
14592000000	0	332	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
14592000000	0	249	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
14606000000	0	257	Optus Mobile	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
15155500000	26	251	Optus Mobile	Manar North 3721 Kings Hwy BUNGENDORE	55	733451	6095261
15155500000	17	71	Optus Mobile	Gumnut Highland Cattle Stud Kings Highway	55	717644	6090407
15194000000	39	313	Optus Mobile	Manar North 3721 Kings Hwy BUNGENDORE	55	733451	6095261
15194000000	25	133	Optus Mobile	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
15194000000	10	4.3	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
15236000000	0	332	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
15236000000	0	249	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
15250000000	0	257	Optus Mobile	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
18428750000	35	060	Optus Mobile	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
18428750000	30	240	Optus Mobile	Federal Hwy The Grove GEARYS GAP	55	716267	6111967
18442500000	18	314	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
18630000000	18	262	Telstra	Old Goldmines Rd off Federal Highway	55	704553	6099079
18662500000	31	35	Telstra	Kings Highway 7.5 km SW of BUNGENDORE	55	717848	6089404
18662500000	9	215	Telstra	Telstra Exchange Rutledge St BUNGENDORE	55	722224	6095404
18662500000	9	297	Telstra	Forestry Commission Fire Tower KOWEN FOREST	55	706660	6093770
18670000000	30	47	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
18677500000	32	36	Telstra	Kings Highway 7.5 km SW of BUNGENDORE	55	717848	6089404
18677500000	10	216	Telstra	Telstra Exchange Rutledge St BUNGENDORE	55	722224	6095404
18677500000	28	339	Vodafone	6 Kealman Street QUEANBEYAN	55	700600	6085500
18750000000	18	262	Telstra	Old Goldmines Rd off Federal Highway	55	704553	6099079
19438750000	35	060	Optus Mobile	Optus Site Lot 5 Shepard Road Gundaroo BYWONG	55	708432	6107716
19438750000	30	240	Optus Mobile	Federal Hwy The Grove GEARYS GAP	55	716267	6111967

FREQ_ASS	ANT_HGT	ANT_AZ	LICENSEE	LOCATION	ZONE	EAST	NORTH
19452500000	18	314	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
19672500000	31	35	Telstra	Kings Highway 7.5 km SW of BUNGENDORE	55	717848	6089404
19672500000	9	215	Telstra	Telstra Exchange Rutledge St BUNGENDORE	55	722224	6095404
19672500000	9	297	Telstra	Forestry Commission Fire Tower KOWEN FOREST	55	706660	6093770
19680000000	30	47	Optus Mobile	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
19687500000	32	36	Telstra	Kings Highway 7.5 km SW of BUNGENDORE	55	717848	6089404
19687500000	10	216	Telstra	Telstra Exchange Rutledge St BUNGENDORE	55	722224	6095404
19687500000	28	339	Vodafone	6 Kealman Street QUEANBEYAN	55	700600	6085500
22022000000	25	297	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
22022000000	6	272	Volante	40 Laverton Ave FAIRBAIRN	55	700382	6090568
23254000000	25	297	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
23254000000	6	272	Volante	40 Laverton Ave FAIRBAIRN	55	700382	6090568
37509500000	35	314	Vodafone	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
37509500000	30	134	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
37509500000	11	003	Optus Mobile	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
37509500000	25	183	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
37516500000	13	249	Optus Mobile	20 Silva Ave QUEANBEYAN	55	704197	6086554
37516500000	24	69	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
37912000000	13	249	Optus Mobile	20 Silva Ave QUEANBEYAN	55	704197	6086554
37912000000	24	69	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
38769500000	35	314	Vodafone	Optus Site Marked Tree Road Chaton Ridge	55	718054	6130657
38769500000	30	134	Vodafone	Win Site Chaton Ridge LAKE GEORGE	55	717370	6131340
38769500000	11	003	Optus Mobile	Broadcast Site MT JERRABOMBERRA	55	701130	6083080
38769500000	25	183	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
38776500000	13	249	Optus Mobile	20 Silva Ave QUEANBEYAN	55	704197	6086554
38776500000	24	69	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555
39172000000	13	249	Optus Mobile	20 Silva Ave QUEANBEYAN	55	704197	6086554
39172000000	24	69	Optus Mobile	Optus Site Stuart Street QUEANBEYAN	55	701305	6085555

ATTACHMENT 3 – MAP OF POINT TO POINT RADIO SYSTEMS NEAR CAPITAL WIND FARM



ATTACHMENT 4 PATH PROFILE MICROWAVE SYSTEM BUNGENDORE – GEARYS GAP



Bungendore(Op)	
Latitude	35 15 24.85 S
Longitude	149 34 02.36 E
Azimuth	312.71°
Elevation	817 m ASL
Antenna CL	39.0 m AGL

Frequency (MHz) = 15000.0
K = 1.33
%F1 = 100.00

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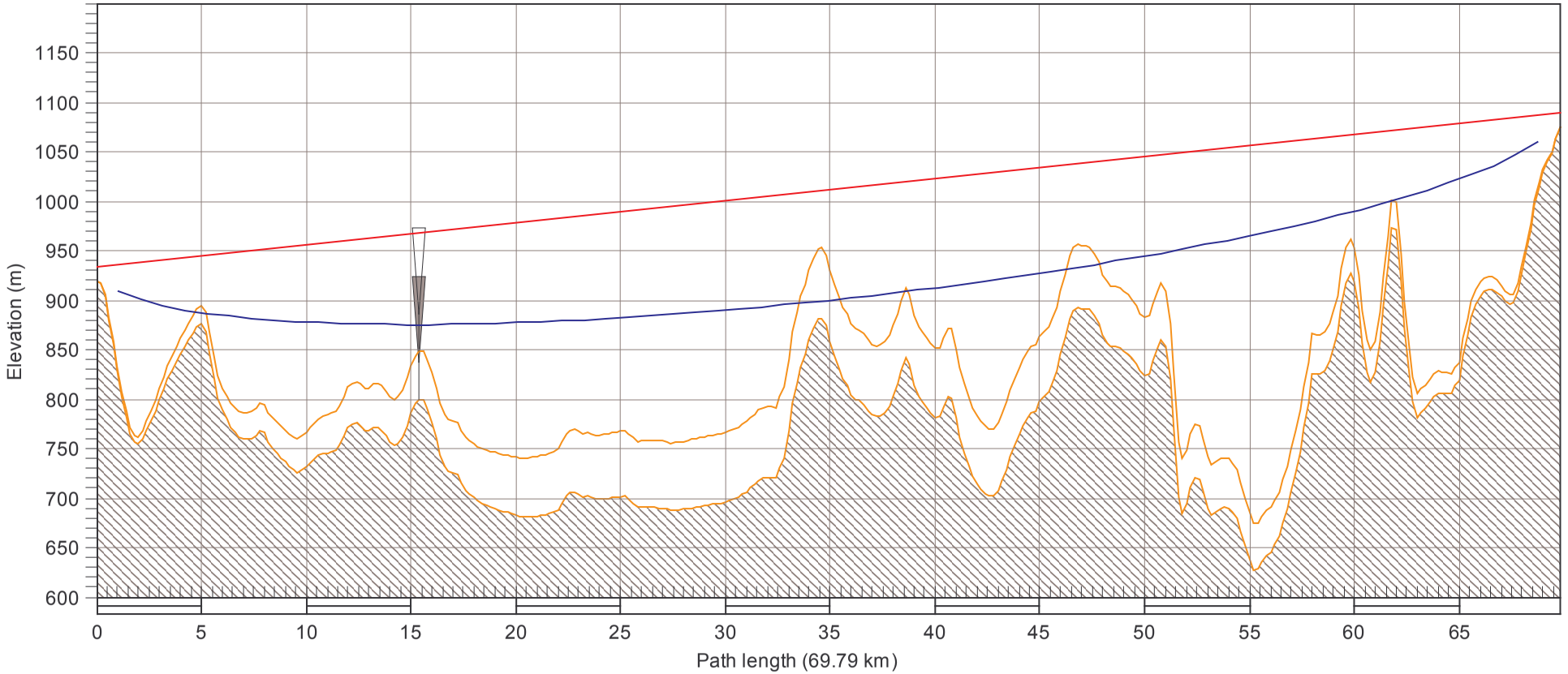
Gearys Gap	
Latitude	35 06 36.91 S
Longitude	149 22 27.13 E
Azimuth	132.82°
Elevation	747 m ASL
Antenna CL	25.0 m AGL

	Jan 26 05	

ATTACHMENT 5 PATH PROFILE UHF LINK COWLEY HILLS – GIBRALTAR HILL



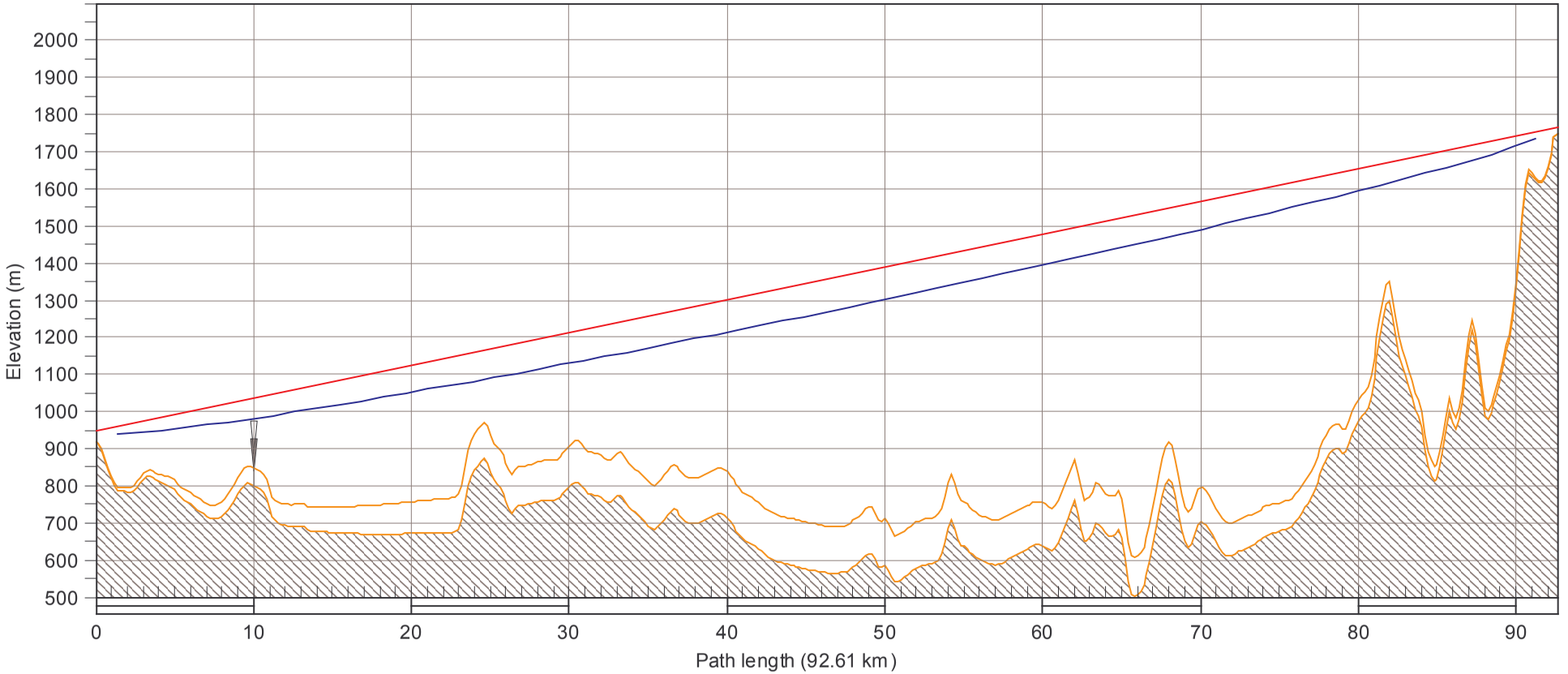
Cowley Hills	
Latitude	35 02 28.87 S
Longitude	149 35 54.13 E
Azimuth	213.13°
Elevation	919 m ASL
Antenna CL	15.0 m AGL

Frequency (MHz) = 414.0
K = 1.33
%F1 = 100.00

Gibraltar Hill	
Latitude	35 34 02.50 S
Longitude	149 10 39.33 E
Azimuth	33.38°
Elevation	1075 m ASL
Antenna CL	15.0 m AGL

	Jan 26 05	

ATTACHMENT 6 PATH PROFILE UHF LINK COWLEY HILLS – MT GININI



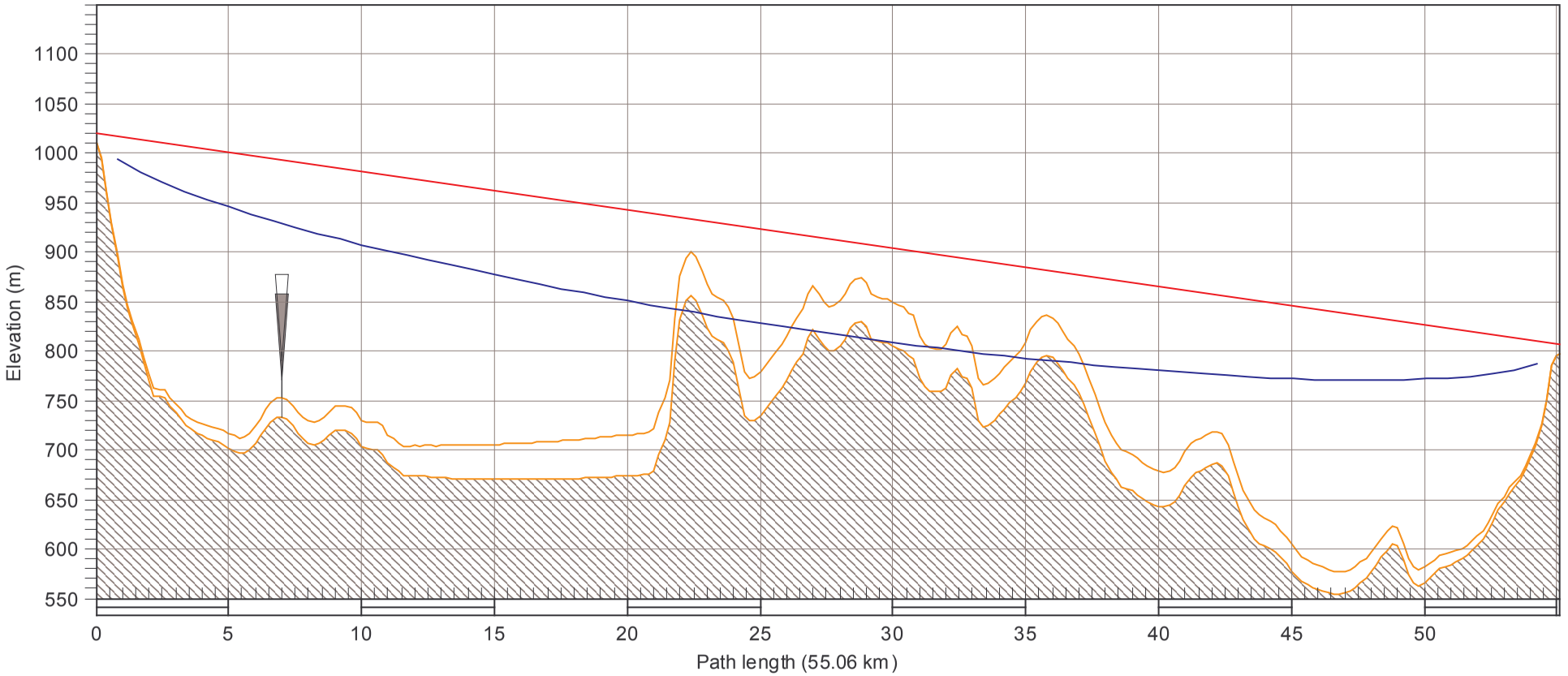
Cowley Hills	
Latitude	35 02 28.87 S
Longitude	149 35 54.13 E
Azimuth	233.97°
Elevation	919 m ASL
Antenna CL	30.0 m AGL

Frequency (MHz) = 853.0
K = 1.33
%F1 = 100.00

Mt. Ginini	
Latitude	35 31 46.39 S
Longitude	148 46 21.40 E
Azimuth	54.45°
Elevation	1748 m ASL
Antenna CL	20.0 m AGL

	Jan 26 05	

ATTACHMENT 7 PATH PROFILE UHF LINK MT ALLIANOYONYIGA – ISAACS RIDGE



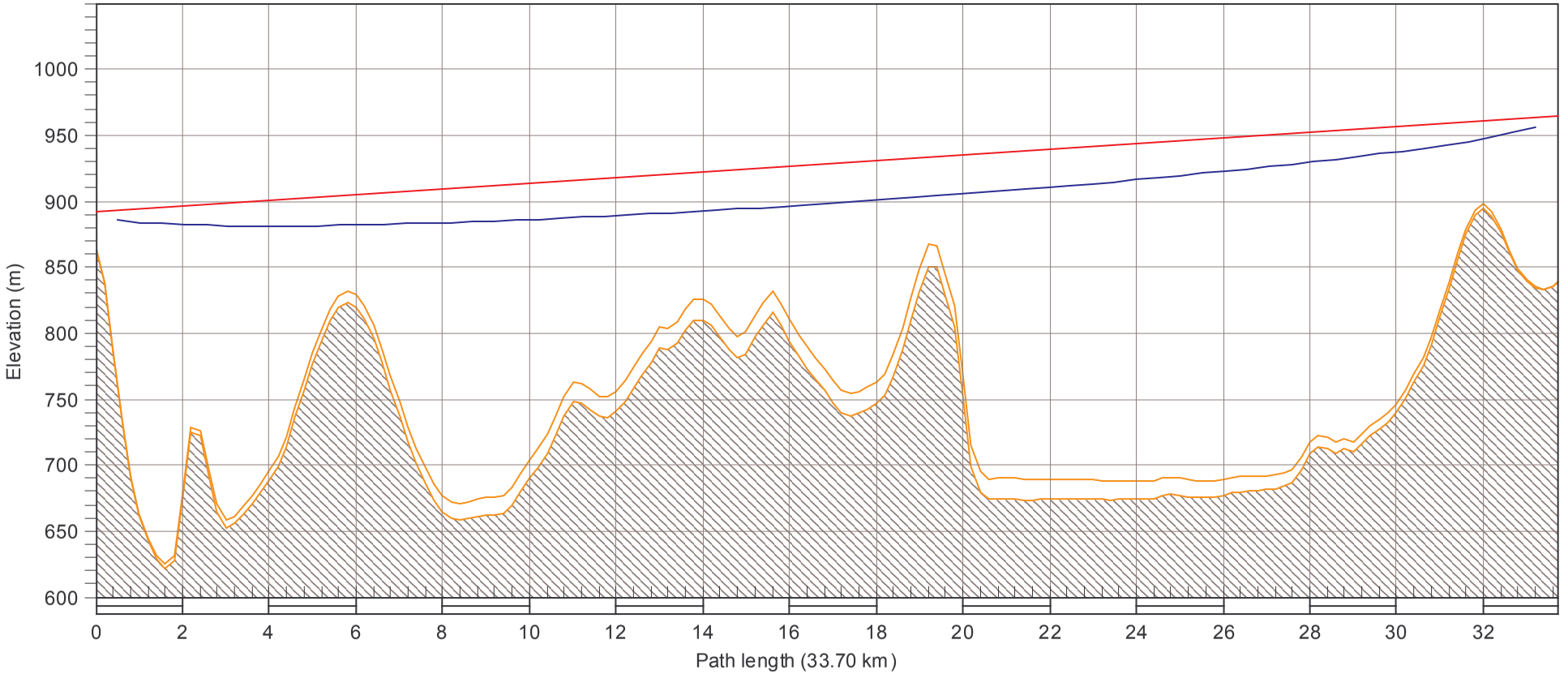
Mt Allianoyonyiga	
Latitude	35 02 15.63 S
Longitude	149 33 48.99 E
Azimuth	226.49°
Elevation	1010 m ASL
Antenna CL	10.0 m AGL

Frequency (MHz) = 450.0
K = 1.33
%F1 = 100.00

Isaacs Ridge	
Latitude	35 22 42.90 S
Longitude	149 07 26.86 E
Azimuth	46.74°
Elevation	797 m ASL
Antenna CL	10.0 m AGL

	Jan 26 05	

ATTACHMENT 8 PATH PROFILE MT MAJURA RADAR – CAPITAL WIND FARM TYPICAL TURBINE



Mt Majura	
Latitude	35 14 14.61 S
Longitude	149 10 56.37 E
Azimuth	75.50°
Elevation	862 m ASL
Antenna CL	30.0 m AGL

Frequency (MHz) = 2800.0
K = 1.33
%F1 = 100.00

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Osborne 56	
Latitude	35 09 38.82 S
Longitude	149 32 25.71 E
Azimuth	255.29°
Elevation	839 m ASL
Antenna CL	125.0 m AGL

	Jan 26 05	

ATTACHMENT 9 - LINK DATA AND CLEARANCES

Four links are on bearings with ray lines near to or crossing the wind farm site. Attachment 3 shows the link paths around and within the wind farm area. In some cases there is sufficient vertical clearance and in other cases there is sufficient horizontal clearance. A Path profile of the one microwave link from Bungendore to Gearys Gap is shown in Attachments 4 and the UHF links profiles are shown in Attachments 5, 6 & 7. A representative turbine of total height to the blade tip of 124 metres is shown in each profile although a turbine is not necessarily on the ray lines or in the position shown. It does indicate that vertical clearance may be achieved for the microwave systems but not in the case of the UHF systems. The Optus registered link is a microwave multichannel systems and the other three are UHF links mainly of single channel capacity operated by the NSW Rural Fire Service and the Ambulance service.

For static obstructions eg hills, trees, buildings on a microwave path, the normal clearance applied between the ray line of the system and the obstruction is 0.6 to 1.0 times the first fresnel zone clearance. In the case of a moving obstruction eg generator blades two references which consider the specific case of wind generators have been studied (Ref's 1& 8). Ref. 1 suggests a clearance of 3 times the first fresnel zone distance and Ref. 8 suggests a clearance of the second fresnel zone. As the generator rotates the signal level due to diffracted signals from the generator causes a time variation of signal level and phase which will cause errors in the transmission of information on the link. A static obstruction generally causes a permanent reduction in signal level. For the time variant case the receiver cannot effectively demodulate the signal and therefore a greater clearance is recommended to reduce the signal variations to acceptable low levels. The type of modulation used in the links will also be a factor in its performance under variation in signals and the path design has to also take into account the natural fading which occurs on microwave links.

Clearances suggested in both references are in the class of good practice to reduce the probability of reducing the link capability for an unacceptable percentage of the time. The blades, due to the generator response to wind direction, will also increase or decrease their clearance from the radio link ray line. The clearance applies to all planes from the ray line so both horizontal and vertical clearance is to be applied.

In the event of a point to point system passing near a generator the recommended clearance from link ray line to generator blade tip of three times the first fresnel zone radius (Ref 1) is calculated using the following formula:

$$Ymin = 3\sqrt{\lambda\, D1\, (1-D1/D2)}$$

Where λ is wavelength = 300/frequency (MHz)
D1 metres is distance to nearest terminal
D2 metres is total link distance

For the Optus microwave linklink the clearance required is calculated as follows:

Link Frequency is 15000 Mhz
D1 = 12 Km say

D2 = 24 Km

Ymin = 3 SQRT (300/15000 X 12000(1-12.0/24.0))
= 32.9 metres

If the generator blades are 44 metres long the clearances from the ray line to all generator tower centre lines are to be at least 44 +32.9 = 76.9 metres. Some adjustment of this clearance will be required depending on the actual distance from the repeater Site to the obstructing generators. A vertical clearance from the turbine hub to the ray line of the same distance is required where horizontal separation is not sufficient.

For Ref. 8 the second fresnel zone clearance is :

Ymin = SQRT (2X300/15000 X 12000(1-12.0/24.0))
= 15.5 metres
The generator tower centre line clearance to the ray line would then be 44 + 15.5 =59.5 metres.

A rigorous analysis is difficult to carry out to determine which clearance is essential. It is believed that the lesser 59.5 metre clearance is adequate.

TABLE SHOWING CALCULATED CLEARANCES FOR LINKS NEAR CAPITAL WIND FARM

Radio Site 1	Radio Site 2	Calc.Bearing deg. T from site 1	Link Freq. Band MHz	Calculated Clearance in metres reqd at 1km	Calculated clearance in metres reqd at 10 km	Total Radio Path Length km
Bungendore	Gearys Gap	312.71	15000	6.2	15.3	24.0
Cowley Hills	Gibraltar Hill	213.32	400	38.5	113.4	69.8
Cowley Hills	Mt Ginini	234.83	900	25.7	77.1	92.6
Mt Allianoyonyiga	Isaacs Ridge	226.49	450	36.2	104.5	55.1

To determine the clearance from the radio ray line to the centre of a turbine tower the blade length must be added added eg for the Bungendore – Gearys Gap Link the clearance required is 15.3 + 44 =59.3 Metres at 10 km from the radio repeater for a 44 metre blade length.

The grid references of radio sites in the ACMA Data Base are based on AMG 66 and the stated accuracy lies between 10 metres and 100 metres for individual radio structures. The current 63 turbine layout has been analysed and sufficient clearance exists between the turbines and the radio ray lines. For the Cowley Hills to Mt Ginini path the closest turbines No's 7 & 8 have calculated clearances of 118 and 178 metres respectively. The Cowley Hills to Gibraltar Hill path is closest to turbine No's 35 & 36 with clearances of 220 and 287.5 metres respectively. For Mt Allianoyonyiga to Isaacs Ridge the calculated clearances to the nearest turbines 2 & 4 are 557 and 337 metres respectively. Should any further revision be made of the turbine positions the

resolution of any potentially obstructed radio paths may need confirming surveys of the radio tower positions.

ATTACHMENT 10 – PREDICTED INTERFERENCE LEVELS TO TELEVISION RECEPTION

The estimates below of reflection of TV signals from generator blades use the formulas in Ref.1 and the details of a Suzlon S88 generator has been used. This is a three bladed 44 metre radius rotor on a tower of 80 metres in height. Information from Suzlon Energy Australia suggests that the blades have the following details:

Planform Area of each Blade approx 67 m² (calculated)
Coning Angle 4.3 degrees
Twist of Blade 9.9 degrees
Lightning Protection bus inside Blade 60mm² stainless steel

Signal Scattering Efficiency η_S

η_S = 0.8x0.41 x exp(- 2.3Δβ) for non-metallic blades

$\Delta\beta$ = total blade twist = 9.9/180 x π

η_S = 0.8 x 0.41 x 0.67206

= 0.2204

lightning protection 60mm² cable could increase efficiency by 20% so

η_S = 0.264

For VHF TV at on say Channels 7 & 9 (190 Mhz)

Effective Number of Blades for receiver in the back scattering zone

$$B_e = 1 + \sin c\left\{\frac{2\pi R}{\lambda}\sin(2\theta)\cos(k)\right\} \le B_e \max$$

$k = \phi_{RT}/2$ for backward scatter zone

$k = 2\phi_{RT}$ for forward scatter zone

$$B_e = 1 + \sin c\left\{\frac{2\pi 44}{300/190}\sin 2x4.3\right\}$$

= 1.8672

where $B_e \max = 1 + \frac{\lambda R}{A_P}$ (Note 1.)

= 1 + 300/190x44/67 = 2.0369

therefore B_e = 1.8672 is applicable

$$Z_I = \eta_S \frac{B_e A_P}{\lambda D}\cos(k)$$

= 0.264x1.8672x67x190/(300x1000) for D = 1km for the maximum directions

= 0.020917

= -33.6db

= 0.264x1.8672 x67x190/(300x250) for D = 250m for the maximum directions

= .083668
= -21.5db

The required wanted to unwanted signal ratio for a just perceptibly degraded TV picture as a function of the time difference between the wanted and unwanted signals is shown in Fig. 2 of Ref. 4 and varies between 28db (<1μs delay) and 34db(>5μs delay). If it was assumed that the wanted signal strength at the residents' TV antennas was the same as at the generator centre, from the above signal scatter ratio estimates perceptible TV picture degradation would occur up to near 500 metres from generators in the forward scatter area. No TV receiving antenna discrimination is possible in the forward scatter case. As, in fact, the signals at the lower height TV antennas in the close in areas will be lower than at the 80m generator height by, for example 6 db, perceptible interference up to 1.0 Km is predicted.

Similar estimates have been made for other UHF channels. The signal scatter ratios for representative UHF channels are summarised below:
Channel 65 (765 MHz) at 1Km $Z_I = -26.8db$
Channel 34 (570 MHz) at 1Km $Z_I = -29.5db$

The calculations also show that at 250m
Channel 65, $Z_I = -14.8db$.
Channel 34, $Z_I = -17.5db$.

These figures indicate that there is a potential for interference for the UHF channels up to and beyond 1.5 Km from the generators in the forward scatter region.

Scatter from multiple generators would be additive to some degree at each receiver.

Note1. The formula for $B_{e,\max}$ was established for a 3 bladed generator in a recent exchange of emails with Prof. Sengupta, of the University of Michigan, USA, one of the Authors of Ref.1.

ATTACHMENT 11 - GLOSSARY OF TECHNICAL TERMS

VHF	Very High Frequency
UHF	Ultra High frequency
EMI	Electromagnetic Interference
VHF Channels	TV Channels 0 to 12 (45 - 230 Mhz)
UHF Channels	TV Channels 28 - 46 (526 - 820 Mhz)
Band III	VHF TV Channels 5A - 12
First Fresnel Clearance	Clearance to obstructions from the ray line on a radio path which does not produce any additional loss above free space loss
FM	Frequency Modulation
MF	Medium Frequency
LF	Low Frequency (not used for sound broadcasting in Australia)
GSM	European Digital Cellular Mobile System
CDMA	Code Division Multiple Access Cellular Mobile System
ITU	International Telecommunications Union
ACMA	Australian Communications & Media Authority
CB Radio	Citizens Band Radio
Space Diversity	Use of additional spaced antennas on a microwave tower to provide an uncorrelated source of signal during signal fading